CLAIMS

We claim:

1. A method of determining inter-field overlay error of a stage on a projection imaging tool, the method comprising:

exposing a first reticle pattern onto a substrate with a recording media, thereby producing a first exposure, wherein the first reticle pattern includes at least two arrays of alignment attributes such that the arrays of alignment attributes have features complementary to each other and the arrays are offset from each other in distinct directions;

exposing a second reticle pattern onto the substrate thereby producing a second exposure, wherein the second reticle pattern overlaps the first reticle pattern and is shifted in a desired direction so that a single row or column of alignment attributes of the first exposure overlays with a single row or column of complementary attributes of the second exposure, thereby creating an interlocking row or column of completed attributes;

measuring positional offsets of the alignment attributes in the interlocking row or column of completed attributes; and

determining a stage overlay error map from the offsets.

2. A method as defined in Claim 1, wherein the substrate is a semiconductor surface.

3. A method as defined in Claim 1, wherein the substrate is a silicon wafer.

4. A method as defined in Claim 3, wherein the silicon wafer is a notched wafer.

5. A method as defined in Claim 1, wherein the substrate is a flat panel display.

6. A method as defined in Claim 1, wherein the substrate is a reticle.

7. A method as defined in Claim 1, wherein the substrate is a photolithographic mask.

8. A method as defined in Claim 1, wherein the substrate is an electronic recording media.

9. A method as defined in Claim 1, wherein the projection imaging tool is used in a photolithographic stepper system.

10. A method as defined in Claim 1, wherein the projection imaging tool is used in a photolithographic scanner system.

11. A method as defined in Claim 1, wherein the projection imaging tool is used in an electron beam imaging system.

12. A method as defined in Claim 1, wherein the projection imaging tool is used in a direct write machine.

13. A method as defined in Claim 1, wherein the projection imaging tool is used in a scalpel tool.

14. A method as defined in Claim 1, wherein the projection imaging tool is used in an extreme ultra-violet imaging apparatus.

15. A method as defined in Claim 1, wherein the projection imaging tool is used in a x-ray imaging system.

16. A method as defined in Claim 1, wherein the projection imaging tool is used in an ion projection lithography tool.

17. A method as defined in Claim 1, wherein measuring positional offsets of the alignment attributes in the interlocking row or column uses an optical overlay tool.

18. A method as defined in Claim 1, wherein measuring positional offsets of the alignment attributes in the interlocking row or column uses a stepper wafer stage and alignment system.

19. A method as defined in Claim 1, wherein measuring positional offsets of the alignment attributes in the interlocking row or column uses a scanner wafer stage and alignment system.

20. A method as defined in Claim 1, wherein measuring positional offsets of the alignment attributes in the interlocking row or column uses a digital CCD.

21. A method as defined in Claim 1, wherein measuring positional offsets of the alignment attributes in the interlocking row or column uses an electronic measurement system.

22. A method as defined in Claim 1, wherein the recording media is a positive resist material.

23. A method as defined in Claim 1, wherein the recording media is a negative resist material.

24. A method as defined in Claim 1, wherein the recording media is an electronic CCD.

25. A method as defined in Claim 1, wherein the recording media is a diode array.

26. A method as defined in Claim 1, wherein the recording media is a liquid crystal material.

27. A method as defined in Claim 1, wherein the recording material is an optically sensitive material.

28. A method as defined in Claim 1, further comprising a chrome patterned glass reticle containing the arrays of alignment attributes.

29. A method as defined in Claim 1, further comprising a SCALPEL reticle containing the arrays of attributes.

30. A method as defined in Claim 1, further comprising an extreme ultra-violet reticle containing the arrays of attributes.

31. A method as defined in Claim 1, further comprising a reflective mask reticle containing the arrays of attributes.

32. A method as defined in Claim 1, wherein the alignment attributes comprise a box- inbox pattern.

33. A method as defined in Claim 1, wherein the alignment attributes comprise a frame-in-frame pattern.

34. A method as defined in Claim 1, wherein the alignment attributes comprise a segment-in-segment pattern.

35. A method as defined in Claim 1, wherein exposing the reticle pattern is at an exposure level below the minimum exposure dose of the recording media.

36. A method as defined in Claim 35, wherein the reticle pattern is exposed a desired number of times.

37. A method as defined in Claim 1, wherein the first reticle pattern is the same as the second reticle pattern.

38. A method as defined in Claim 1, further comprising:

exposing the second reticle pattern onto the substrate in a subsequent exposure such that the pattern of the subsequent exposure overlaps the second exposure;

repeating subsequent exposures such that each subsequent exposure overlaps a previous exposure.

39. A method as defined in Claim 38, wherein repeating subsequent exposures produces a series of exposures that covers a desired portion of the substrate.

40. A method as defined in Claim 38, wherein repeating subsequent exposures produces a series of exposures that covers the entire surface of the substrate.

41. A method as defined in Claim 38, wherein one or more of the exposures on the substrate includes less than the entire pattern.

42. A method of determining inter-field overlay error of a stage on a projection imaging tool, the method comprising:

exposing a first reticle pattern onto a substrate with a recording media;

exposing a second reticle pattern onto the substrate, wherein the second reticle pattern overlaps the first reticle pattern and is shifted in a desired direction so that a single row or column of alignment attributes of the first exposure overlays with a single row or

column of complementary attributes of the second exposure thereby creating an interlocking row or column of completed attributes;

measuring positional offsets of the alignment attributes in the interlocking row or column;

providing additional substrates with recording media and repeating the steps of exposing a first reticle pattern, and exposing a second reticle pattern, and measuring the positional error for a desired number of substrates; and

determining a stage overlay error map by averaging the positional offsets of the desired number of substrates.

43. A method of determining inter-field overlay error of a stage on a projection imaging tool, the method comprising:

providing a reticle with a pattern of at least two arrays of alignment attributes, wherein the arrays of alignment attributes have features complementary to each other and the arrays are offset from each other in distinct directions;

exposing a first reticle pattern, using an exposure level below a minimum dose, onto a substrate with a recording media;

exposing a second reticle pattern, using an exposure level below a minimum dose, onto the substrate, wherein the second reticle pattern overlaps the first reticle pattern and is shifted in a desired direction so that a single row or column of alignment attributes of the first exposure overlays with a single row or column of complementary attributes of the second exposure thereby creating an interlocking row or column of completed attributes;

repeating exposing the second reticle pattern a desired number of times;

measuring positional offsets of the alignment attributes in the interlocking row or column; and

determining a stage overlay error map from the positional offsets.

44. A reticle used for determining inter-field overlay error of a stage on a projection imaging tool, the reticle comprising:

a first set of alignment attributes disposed along a first column;

a second set of alignment attributes that are complementary to the first set of alignment attributes, the second set of alignment attributes disposed along a second column distinct from the first column, wherein the alignment attributes in the first and second sets are aligned in corresponding rows;

a third set of alignment attributes distributed along a first row between the first and second column; and

a fourth set of attributes complementary to the third set of attributes, the fourth set of alignment attributes disposed in a second row distinct from the first row, wherein the alignments attributes in the third and fourth sets are aligned in corresponding columns.

45. A reticle as defined in Claim 44, wherein the reticle has reduced transmission.

46. A reticle as defined in Claim 45, further comprising a partially reflecting dielectric coating.

47. A reticle as defined in Claim 45, further comprising an attenuated phase shift mask.

48. An apparatus for determining inter-field overlay error of a stage on a projection imaging tool, the apparatus comprising:

means for providing a reticle with a pattern of at least two arrays of alignment attributes, wherein the arrays of alignment attributes have features complementary to each other and the arrays are offset from each other in distinct directions;

means for exposing a first reticle pattern onto a substrate with a recording media;

means for exposing a second reticle pattern onto the substrate, wherein the second reticle pattern overlaps the first reticle pattern and is shifted in a desired direction so that a single row or column of alignment attributes of the first exposure overlays with a single row or column of complementary attributes of the second exposure thereby creating an interlocking row or column of completed attributes;

means for measuring positional offsets of the alignment attributes in the interlocking row or column; and

means for determining a stage overlay error map from the offsets.

49. An apparatus for determining inter-field overlay error of a stage on a projection imaging tool, the apparatus comprising:

means for providing a reticle with a pattern of at least two arrays of alignment attributes, wherein the arrays of alignment attributes have features complementary to each other and the arrays are offset from each other in distinct directions;

means for exposing a first reticle pattern, using an exposure level below a minimum dose, onto a substrate with a recording media;

means for exposing a second reticle pattern, using an exposure level below a minimum dose, onto the substrate, wherein the second reticle pattern overlaps the first

reticle pattern and is shifted in a desired direction so that a single row or column of alignment attributes of the first exposure overlays with a single row or column of complementary attributes of the second exposure thereby creating an interlocking row or column of completed attributes;

means for repeating exposing the first reticle pattern and the second reticle pattern a desired number of times;

means for measuring positional offsets of the alignment attributes in the interlocking row or column; and

means for determining a stage overlay error map from the offsets.

50. A reticle used for determining inter-field overlay error of a stage on a projection imaging tool, the reticle comprising:

means for producing a first set of alignment attributes disposed along a first column;

mean for producing a second set of alignment attributes that are complementary to the first set of alignment attributes, the second set of alignment attributes disposed along a second column distinct from the first column, wherein the alignment attributes in the first and second sets are aligned in corresponding rows;

means for producing a third set of alignment attributes distributed along a first row between the first and second column; and

means for producing a fourth set of attributes complementary to the third set of attributes, the fourth set of alignment attributes disposed in a second row distinct from the first row, wherein the alignment attributes in the third and fourth sets are aligned in corresponding columns.